Physiological strain indicators in OHP field studies

Hard data with uncertain interpretations

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Physiological strain indicators

Entnommen aus: Papastefanou, G. (2008). Stressmessung aus Sicht der empirischen Sozialforschung. Präsentation auf den Karlsruher Stresstagen 4.11. bis 6.11. 2008.

Overview

- Two prominent indicators and how to measure them
  - Saliva cortisol
  - Heart rate variability (HRV)
- Examples of field studies with physiological strain indicators

Bodily stress reaction

- Several systems and indicators
  - Cardiovascular system (e. g. blood pressure, heart rate)
  - Autonomic nervous system (e.g. heart rate variability)
  - Endocrine system (e. g. adrenalin, cortisol)

Salivary Cortisol

- Kortisol is an indicator of the HPA-Axis
- HPA is central for bodily stress responses (Rydstedt, Cropley, & Devereux, 2011)
- Can be measured in urine, blood, hair, and saliva
- For field studies: saliva (hair)

Salivary Cortisol

- Cortisol has a characteristic duirnal rhtyhm: Highest in the early morning, decline until the first half of the night, rise in the second half of the night (Fries et al., 2009)
- Measurement at different time points:
  - Cortisol awakening response
  - Measurement over the day
- Frequency of measurement (Segerstrom et al., 2014):
  - Between-person: 3 days for mean values; 4-8 for AUC; 10 for slope
  - Within-person: 3 days of mean and AUC, 5-8 for slope

Salivary Cortisol

How to decide?

- How are relationships to constructs of interest?
  - For example:
    - Cortisol after awakeing response (CAR) is a reliable marker of HPA activity (Kudielka & Wüst, 2010; Pruessner et al., 1997)
    - Is related to work stress (Chida & Steptoe, 2009)
- Under which circumstances is a complete measurement, with less missing data likely?
- What are my participants willing to do? What is feasible in a work context?
- What values will I report? (How many measurements do I need?)

Compliance

Study by Kudielka et al. (2003):

- Two-groups: Informed vs. noniformed
- Measurement of subjective and objective compliance
- Informed group showed better compliance (subjective and objective)
- Non-Compliance confunds cortisol values
- Non-compliance is heaviest in the morning

Compliance

How to protect against non-compliance?

- Tell participants about the importance
- Tell participants about the importance to be honest
- (Tell participants their compliance is monitored)
- Check compliance

Salivary Cortisol - Example

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Extended Work Availability and Its Relation With Start-of-Day Mood and Cortisol

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The opportunity to work at any time and place, which is facilitated by mobile communication technologies, reinforces employer expectations that employees are available for work beyond regular work hours. This study investigates the relation of daily extended work availability with psychological and physiological well-being and the mediating role of recovery experiences. We hypothesized that recovery is limited under conditions of extended work availability, which may impair well-being. A sample of 132 individuals from 13 organizations provided daily survey measures over a period of 4 days during which they were required to be available during nonworking hours and 4 days during which they were not required to be available. A subsample of 51 persons provided morning cortisol levels in addition to the survey data. The analysis of within-person processes using multilevel structural equation modeling revealed significant effects of extended work availability on the daily start-of-day mood and cortisol awakening response. Mediation analysis revealed that the recovery experience of control over off-job activities mediated the observed relationship with start-of-day mood but not the relationship with the cortisol awakening response. The results demonstrate that nonwork hours during which employees are required to remain available for work cannot be considered leisure time because employees' control over their activities is constrained and their recovery from work is restricted.

Keywords: availability, boundary permeability, cortisol, recovery, work–family border

Salivary Cortisol - Example

Anticipation of a work-related task

- Work-Family-Border Theory (Clark, 2000; Nippert-Eng, 1996): Less control over border permeability
- Not knowing when one is called to perform a task: Anticipatory stress (McGrath & Beehr, 1990)

Study:

- Diary study; four days with on-call, four days without on-call
- N = 132 Persons, 1056 Days
- ML-SEM

Salivary Cortisol - Example

Cortisol measurement

- *Inclusion criteria:* no heavy smoking, no continuous drug intake, no chronic disease, not pregnant or nursing, and no diagnosed insomnia.
- *Control variables:*
  - **Person-level**: negative and positive affect, depression, subjective health and training constitution, body mass index, smoking status, use of contraceptives, and income
  - **Day-level:** waking times (hours after 12 a.m.), physical activity, substance consumption, and medication

Salivary Cortisol - Example

Cortisol measurement

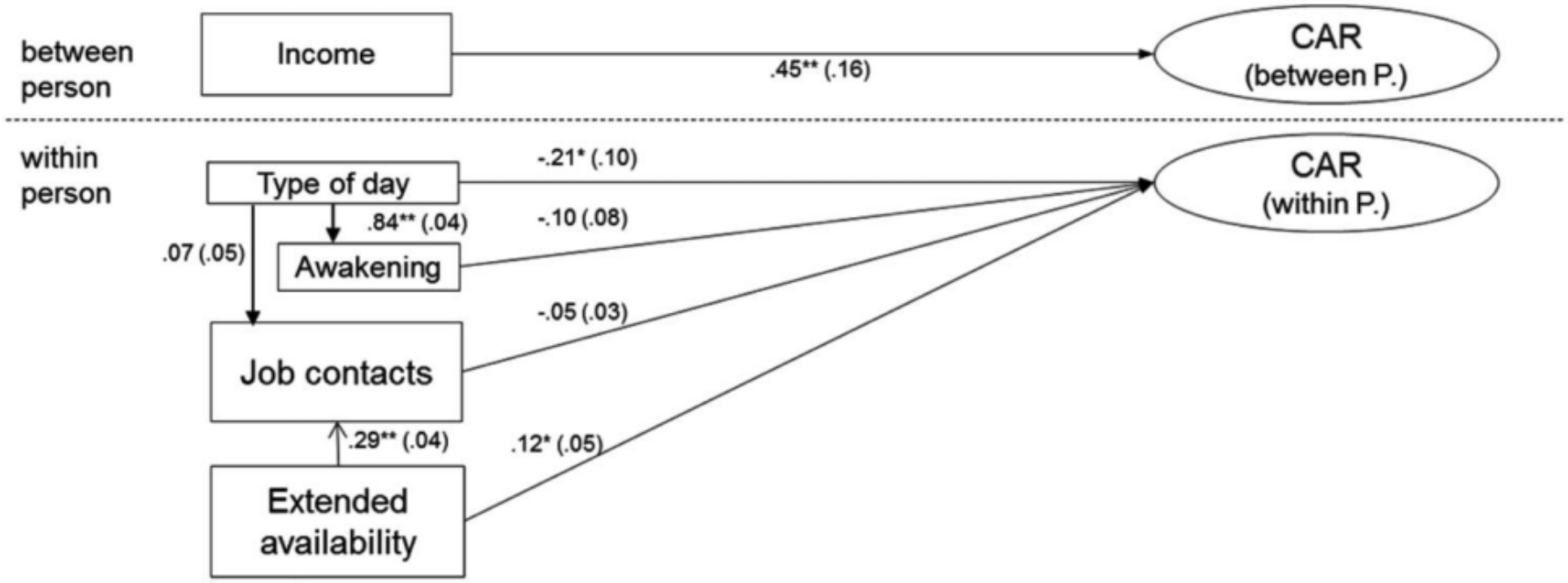
- Cortisol after awakening response (AUCi): Awakening, +15min., +30 min.
- The participants were instructed not to brush their teeth and to refrain from eating or drinking (except water) during the collection of the three morning samples.
- **Compliance check:**
  - Objective awakening time: heart rate and activity data to determine the objective awakening times for each participant and day.
  - Samples were excluded if the objective awakening time and the time of the first saliva sample were more than 10 minutes apart (see Stalder, Evans, Hucklebridge, & Clow, 2011).
  - A total of 14% of the measurement days were excluded, which resulted in a subsample of 346 days.

Salivary Cortisol - Example

Relationship between extended availability and saliva cortisol?

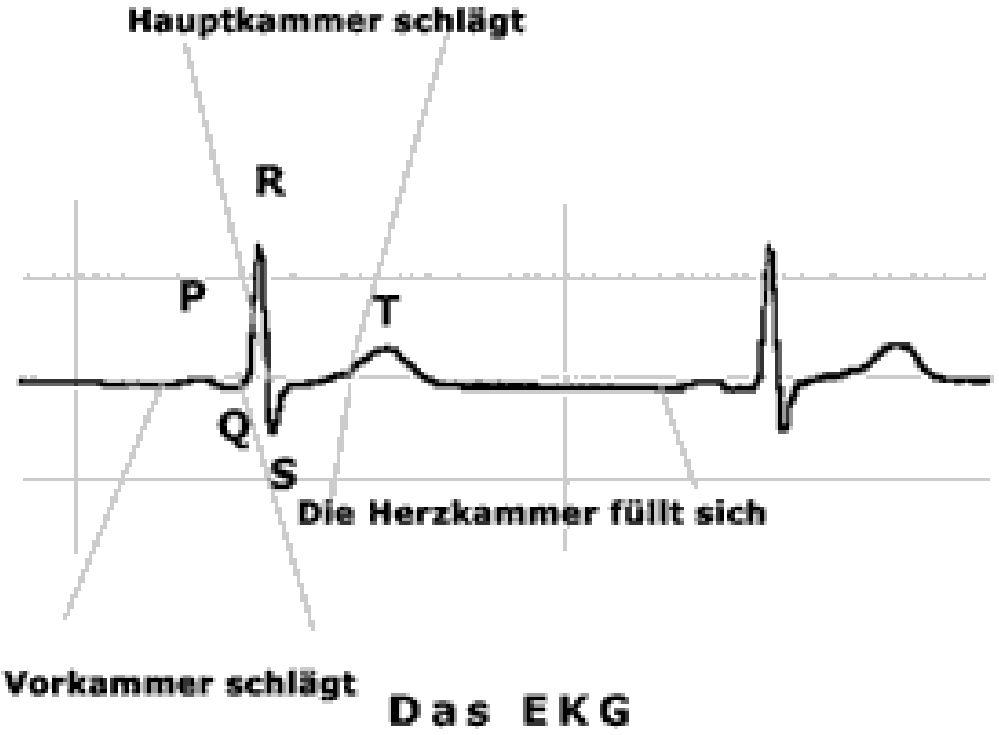
- Extended availability is negatively related to well-being because of uncertainty and less control over spare time activities (Vahle-Hinz et al., 2014)
- Cortisol responses to stress are more likely if (see Mason, 1968, Kirschbaum & Hellhammer, 1994; Dickerson & Kemeny, 2004; Miller, Chen, & Zhou, 2007):
  - Social threatening
  - Uncontrolability
- Some results regarding anticipatory stress (Fries et al., 2009)
- No relationship to evening saliva cortisol in a pre-study (see Bamberg et al., 2012)

Salivary Cortisol - Example



Dettmers, Vahle-Hinz et al., 2016, S. 112

Heart rate variability (HRV)



Heart rate variability (HRV)

- Heartbeats are modulated by the intrinsic activity of the sinus node (around 70 beats per minute)
- Trough innervation of sympathetic and parasympathetic nerves, the ANS can alter the heartbeat and adapt its pace to environmental challenges.
- The resulting variability can be measured as time variations between successive heartbeats, termed heart rate variability (Berntson et al., 1997).

Heart rate variability (HRV)

- Pharmacological receptor blockades, vagotomy, or electric nerve stimulation in animals, have established the physiological meaning of HRV as either sympathetic or parasympathetic (Akselrod et al., 1981; Malliani, Pagani, Lombardi, & Cerutti, 1991).
- The heartbeat is more synchronous with less variability during physical and physiological arousal because the sympathetic modulation of the heart is dominant (Task Force, 1996; Tarvainen & Niskanen, 2008)
- Higher variability occurs during rest and recovery, which is consistent with a predominantly parasympathetic modulation of the heartbeat (Task Force, 1996).
- **Think about riding a bicycle…**

Heart rate variability (HRV)

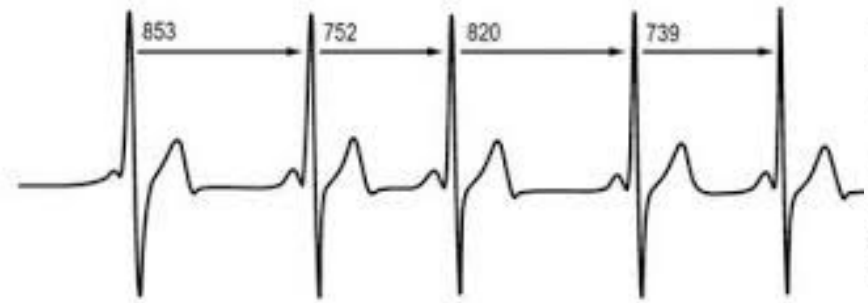
Relationship to several important health outcomes:

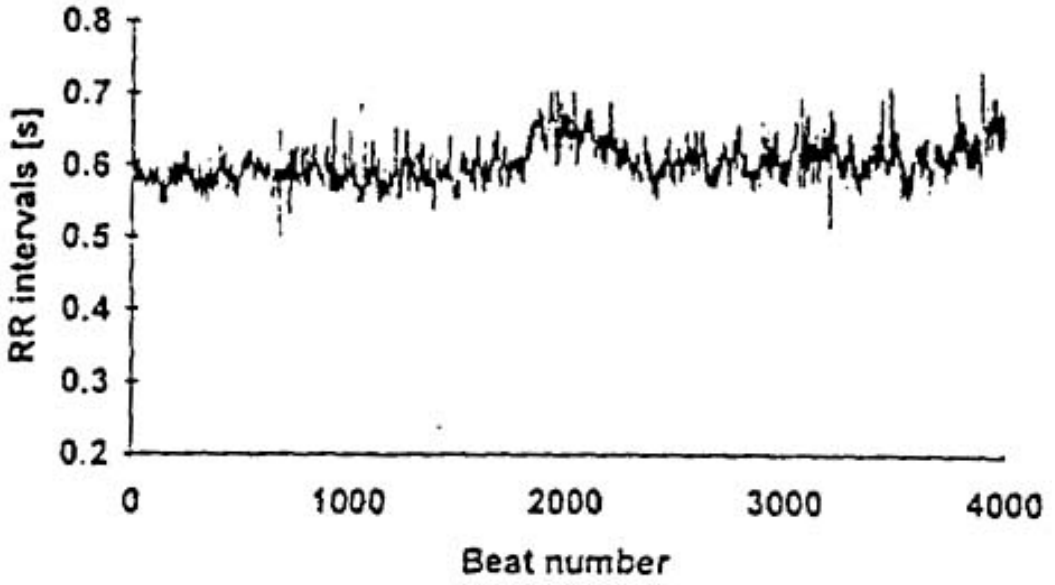
- *Cardiovascular disease* (Singer et al., 1988; Thayer & Lane, 2007; Tsuji et al., 1996), *multiorgan dysfunction* (Pontet et al., 2003), and *diabetes* (Liao et al., 1995)
- *Higher mortality risk* with lower HRV after myocardial infarction (Kleiger, Miller, Bigger, & Moss, 1987; Task Force, 1996; Thayer & Lane, 2007)

Relationship to work stress:

- Lower HRV higher work stress (Chandola, Heraclides, & Kumari, 2010; Togo & Takahashi, 2009).
- Higher ERI, lower HRV (Hintsanen et al., 2007; Loerbroks et al., 2010)
- High strain group, lower HRV (Collins & Karasek, 2010; Kang et al., 2004; van Amelsvoort, Schouten, Maan, Swenne, & Kok, 2000)

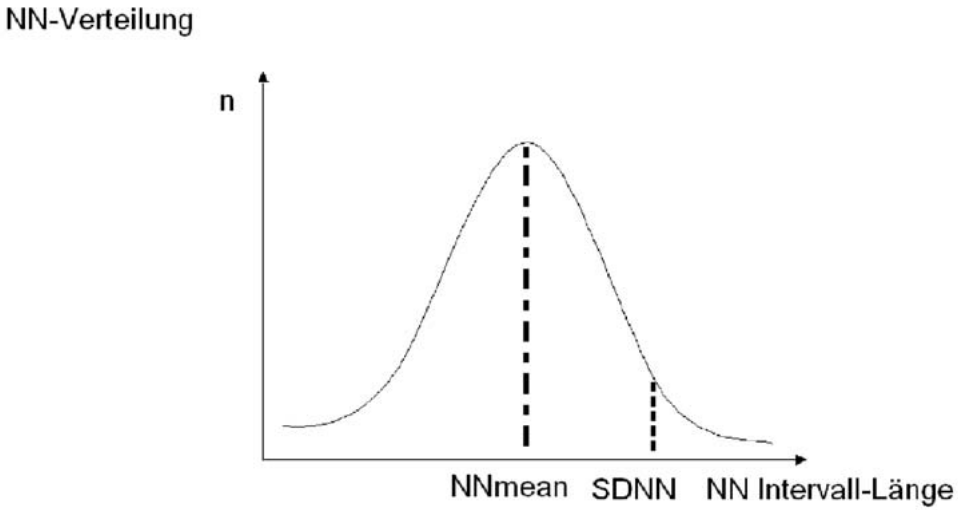
Heart rate variability (HRV) - fundamentals



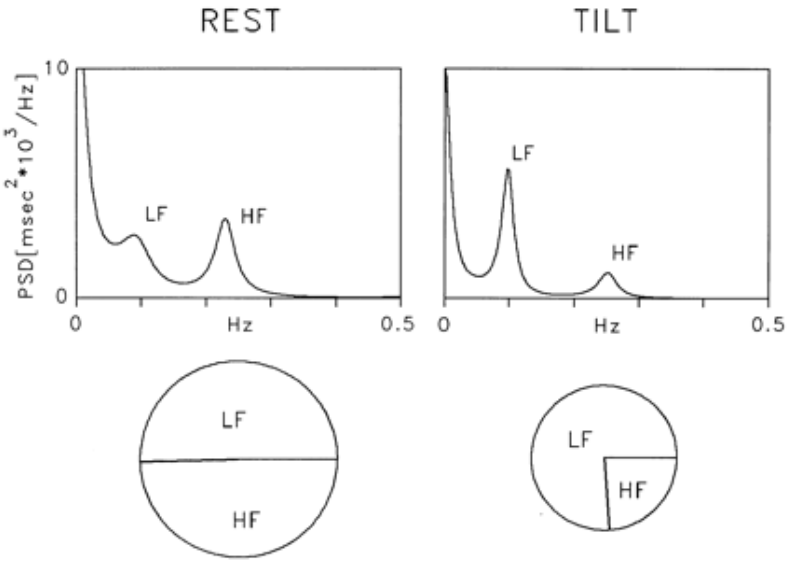


Heart rate variability (HRV) - fundamentals

Time based

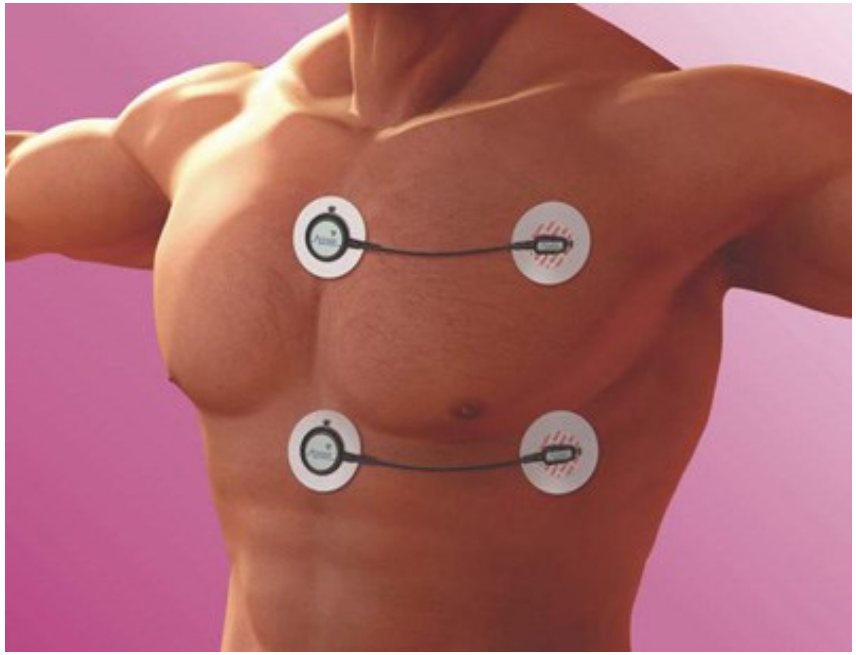


Frequency based



Heart rate variability (HRV) - Measurement

The easy part



Heart rate variability (HRV) - Measurement

The hard part

- R wave detection: mostly algorithm, but inspection is needed (good to have original ECG-signal)
- Selection of measurement sections: 24 hours? 5min.? 60 sec.? Several 5 min. and average over ecological episodes (work, free time, sleep)?
- Artifact processing: Algorithm? Visual inspection? Raw data available (ECG-signal)? Deleting? Interpolation (how?)?

There are very different approaches in current empirical studies; hard to compare one HRV study with another

Heart rate variability (HRV) - Example

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Effects of Work Stress on Work-Related Rumination, Restful Sleep, and Nocturnal Heart Rate Variability Experienced on Workdays and Weekends

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The present study reports the lagged effects of work stress on work-related rumination, restful sleep, and nocturnal heart rate variability experienced during both workdays and weekends. Fifty employees participated in a diary study. Multilevel and regression analyses revealed a significant relationship between work stress measured at the end of a workday, work-related rumination measured during the evening, and restful sleep measured the following morning. Work stress, measured as the mean of 2 consecutive workdays, was substantially but not significantly related to restful sleep on weekends. Work stress was unrelated to nocturnal heart rate variability. Work-related rumination was related to restful sleep on weekends but not on workdays. Additionally, work-related rumination on weekends was positively related to nocturnal heart rate variability during the night between Saturday and Sunday. No mediation effects of work stress on restful sleep or nocturnal heart rate variability via work-related rumination were confirmed.

Keywords: heart rate variability, recovery, restoration, sleep, work stress

Heart rate variability (HRV) - Example

Measurement Times	Workday 1	Workday 2	Workday 3	Saturday	Sunday
Morning	Assessment of restful sleep	Assessment of restful sleep	Assessment of restful sleep		Assessment of restful sleep
Afternoon	Assessment of work stress	Assessment of work stress			
Evening	Assessment of work-related rumination	Assessment of work-related rumination		Assessment of work-related rumination	

Diary study, 50 participants on 100 days, ML-regression and multiple regression

Heart rate variability (HRV) - Example

- *Inclusion criteria:* no heavy smoking, no continuous drug intake, no chronic disease (e.g., rheumatism, diabetes, arteriosclerosis), no pregnant or nursing status, and no insomnia diagnosis.
- *Control variables:*
  - **Person-Level:** contraceptive use, subjective health, condition, subjective fitness household income, season, body mass index, smoking status, depressive mood, positive and negative affect.
  - **Day-Level:** caffeine or tobacco intake, medication use, time falling asleep (operationalized as the hours since midnight of the previous day), hours slept that night, amount of available data for analysis, and high physical effort during the day

Heart rate variability (HRV) - Example

HRV measurement:

- Actiheart monitor (Cambridge Neurotechnology, Cambridge, U.K.) to assess nocturnal HRV.
- ECG was sampled with a frequency of 128 Hz, but the IBIs were logged using an interpolation with a 1000 Hz resolution; Important no ECG signal was stored

Heart rate variability (HRV) - Example

HRV analysis:

- Objectively and subjectively determined sleep
- Objectively: Rapidly increases of heart rate by approximately 10–15 beats per minute upon awakening (Trinder et al, 2001), and similarly, heart rate decreases at night (Thayer & Lane, 2007)
- 15 min. of every full hour of sleep was used to calculate HRV
- HRV was analyzed in 60 sec. segments and averaged over the sleeping period

Heart rate variability (HRV) - Example

HRV analysis:

- Artifact correction (with ARTiiFACT; Kaufmann, Sütterlin, Schulz, & Vögele, 2011):
  - Visual check and algorithm that uses percentile-based distributions of the individual IBI series (Berntson, Quigley, Jang, & Boysen, 1990)
  - Correction with cubic spline interpolation
  - Segments with more than 10% artifacts according to the median number of beats per 1-min interval in the corresponding sleep period were eliminated from further analyses

Heart rate variability (HRV) - Example

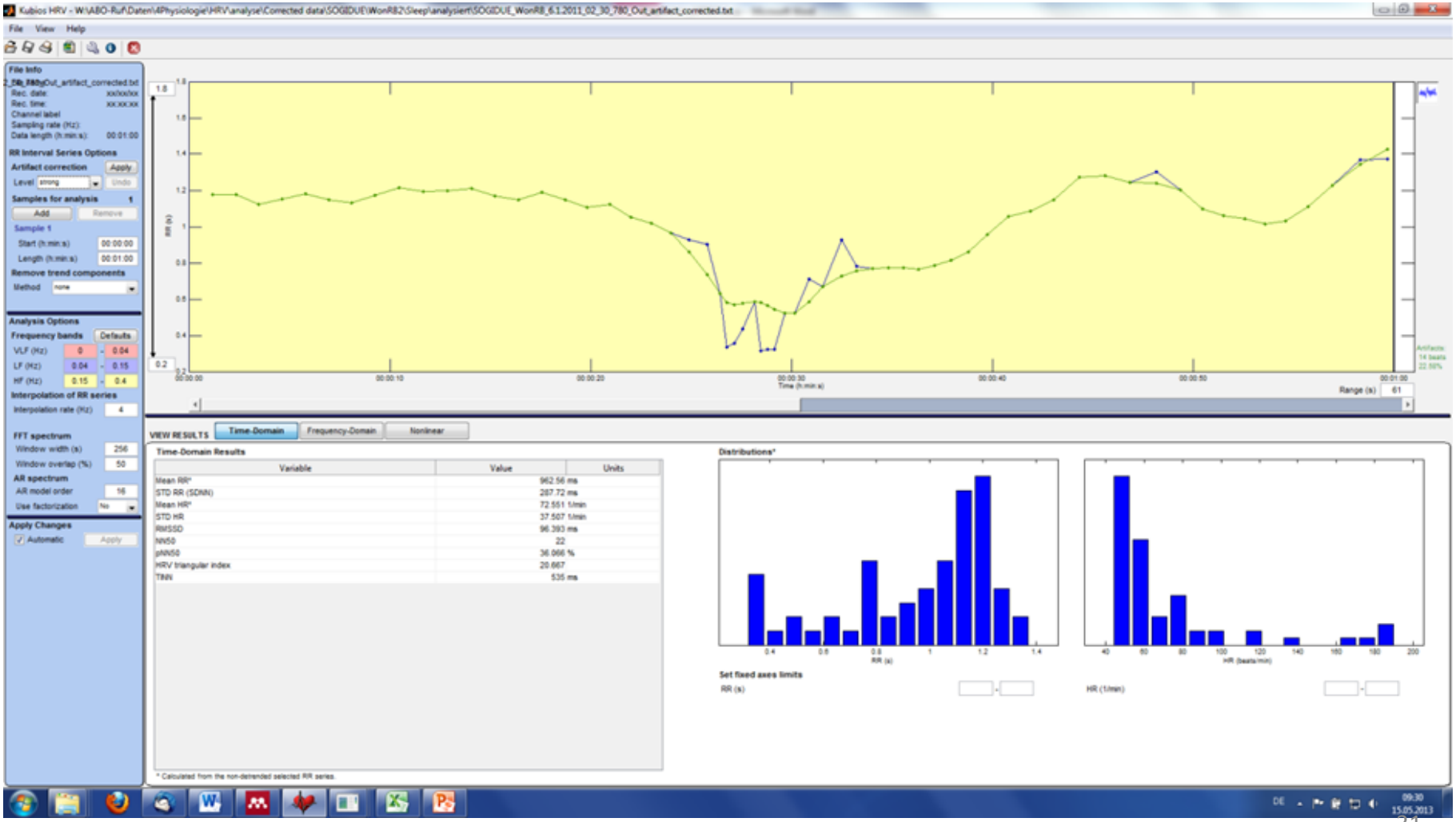
HRV analysis:

- HRV calculation:
  - Done with Kubios HRV (freeware programm; Tarvainen & Niskanen, 2008)
  - However, again a visual check for artifacts. If not sucessfull, exclusion of the segment (At least 90% of the night data had to be available, otherwise exclusion of this night)
  - Calculation of the root mean square of successive differences (RMSSD): Parasympathetic activity, less effected by breathing (Penttilä et al., 2001)

Analysis was in accordance with recommendations of the Task Force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology (1996).

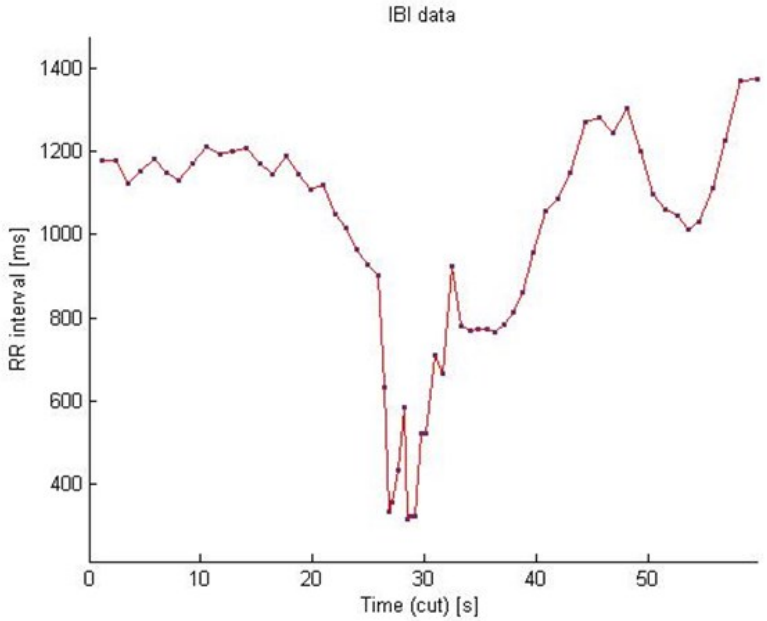
Heart rate variability (HRV) - Example

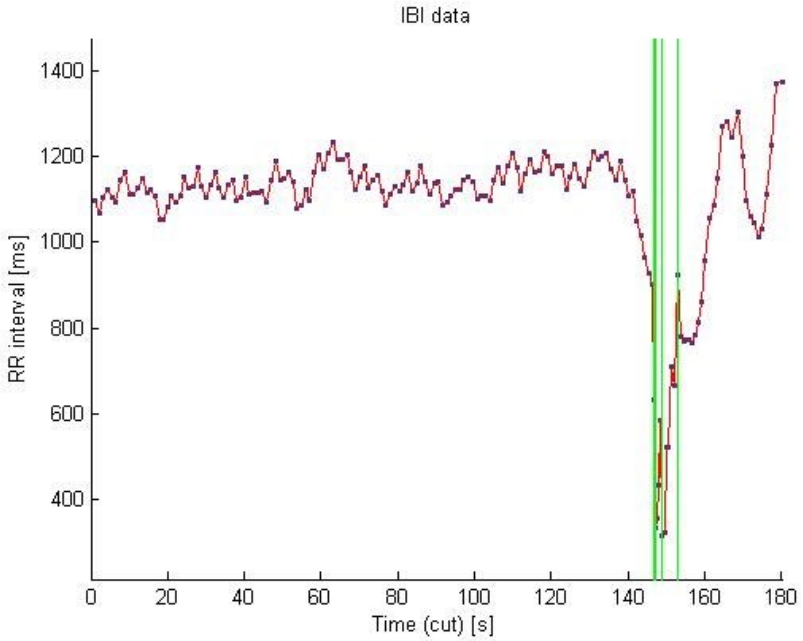
- HRV analysis- some examples



Heart rate variability (HRV) - Example

- HRV analysis- some examples





- Precise correction is necessary
- With ECG signal, physiological meaning can be explored, without, only mathematical decision
- Wrong decisions if only relying on algorithm

Heart rate variability (HRV) - Example

Results

- No effects of work stress on nocturnal HRV! (All the work for nothing?)
- One contradictory finding: Work-related rumination in weekends is positively related to nocturnal HRV

Some concluding thoughts

Hard data:

- Objective bodily reaction (less censored)
- Not retrospective bias (online)
- Continuously measurement (time trends are important)
- Sensitive, no scale limit
- Mechanism between cognitions and behaviors

Some concluding thoughts

But with uncertain interpretations:

- Risk of wrong conclusion: Top-down vs. bottom-up
  - Context free or context specific; specific, sensitive
- Distal assessment of bodily stress systems
- Several confounding factors, that are hard to diminish (e.g. breathing, movement, artifacts)
- Interactions between bodily systems is plausible but impossible to consider
- Meaning of parameters are developing: High cortisol is bad; low and high cortisol is bad
- Time trends and timing of measurement is important, but we do not know much about time courses
- Much knowledge stems form laboratory studies

Some concluding thoughts

- *"Physiological measures are not just another way of gathering data on stress. Rather, physiological systems are bodily sub-systems in their own right, and this has to be taken into account when discussing their validity as measures of stress (…) By contrast, physiological measures are much more than just another way to measure the same phenomena that are measured by self-report regarding well-being (…)"* (Semmer et al., 2004, 224 und 225)

Thank you very much for your attention

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Questions?

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